

A review of agricultural pesticide incidents in man in England and Wales, 1952-71

C. E. D. HEARN¹

Fisons Limited, Agrochemical Division, Cambridge

Hearn, C. E. D. (1973). *British Journal of Industrial Medicine*, 30, 253-258. **A review of agricultural pesticide incidents in man in England and Wales, 1952-71.** An analysis was carried out of the poisoning incidents attributed to pesticides in England and Wales investigated by the Safety Inspectorate of the Pesticides Branch of the Ministry of Agriculture, Fisheries, and Food from 1952 to 1971. All poisoning incidents attributed to pesticides which are reported to the Safety Inspectorate are recorded and separated into reported and confirmed incidents. The confirmed incidents are classified into fatal and non-fatal. The non-fatal incidents are subdivided into four categories, systemic poisoning, eye injuries, dermatitis, and chemical burns.

There were nine fatal cases of poisoning due to pesticides between 1952 and 1971, of which only three were occupational in origin. The remaining six were non-occupational but were investigated by the Safety Inspectorate only because the incident happened to arise on, or in connection with, a farm. The details of all the cases are recorded.

There were 222 non-fatal confirmed incidents during the period, affecting a total of 296 persons. There has been an increased frequency of incidents since 1966 largely attributable to more complete and comprehensive recording by the Safety Inspectorate.

Out of a total of 250 recorded pesticide effects, 121 (48.5%) were systemic poisoning, 57 (22.8%) were eye injuries, 54 (21.6%) were dermatitis, and 18 (7.1%) were chemical burns. Of the 121 incidents of non-fatal systemic poisoning, usually of a mild character, 34 were due to organophosphates, 26 to a single incident involving chloropicrin, 15 to arsenites, eight to dinitro compounds, three to nicotine, two to fungicides, one to cyanide, and one to an organomercury compound. Thirty-one incidents were not classified because the symptoms were non-specific in character and the worker had been exposed to a large number of different chemicals. In some instances the relationship of the symptoms to previous exposure to pesticides was extremely uncertain. Eye injuries and dermatitis were attributable to a wide variety of different chemicals and in the majority of instances were mild. Sulphuric acid, used for potato haulm destruction, was the commonest recorded cause of chemical burns.

The main problems in the use of pesticides in England and Wales today are (1) the illicit decanting of concentrate from the manufacturer's labelled containers, (2) the hoarding of incompletely used containers, (3) the disposal of empty containers, and (4) the importation of pesticides in inadequately labelled containers.

These defined practical problems of safety in application and accident control are perhaps of greater importance than the long-term theoretical toxicological effects of pesticides which may be attracting too much attention today.

Introduction

Between 1946 and 1951 there were eight deaths of agricultural workers in Great Britain, all in contract

spraying operators in hot weather arising from the intensive use of dinitrocresol as a weed killer without adequate safety precautions (Edson, 1955). It was largely as a result of this experience that the Agriculture (Poisonous Substances) Act was passed in 1952. Regulations made under the Act define

¹Present address: Gillette International, London.

the precautions that must be taken when using various specified chemicals, according to both their toxicity and the manner of their use.

An analysis was carried out of the poisoning incidents attributed to pesticides in England and Wales investigated by the Safety Inspectorate of the Pesticides Branch of the Ministry of Agriculture, Fisheries, and Food over the 20 years since the regulations came into force in 1952 up to 1971.

Material and method

The Annual Reports on the Use of Poisonous Substances in Agriculture, and the Working of the Agriculture (Poisonous Substances) Regulations¹, prepared by the Pesticides Branch of the Ministry of Agriculture, Fisheries, and Food have been examined. The poisoning incidents attributed to pesticides, which were investigated by the Safety Inspectorate from 1952 until 1971, have been studied and form the data for the present analysis.

The Safety Inspectorate, who are not medical, nor particularly trained in case studies, record all poisoning incidents attributed to pesticides which are reported to them and separate those into reported and confirmed incidents. Incidents are reported by farmers, agricultural workers, and members of the public, the National Union of Agricultural Workers playing an important and active educative role in alerting its members to pesticide hazards. A confirmed incident is one in which the Safety Inspectorate is satisfied, as a result of their own investigations, that there is a possibility that the incident is genuine. In the case of alleged systemic illness an initial assessment is made by the Pesticide Branch, and the incident is then referred to a medical expert (Dr. J. M. Barnes, Medical Research Council Toxicology Unit, Carshalton, Surrey) for final classification.

The confirmed incidents are classified into fatal and non-fatal. The non-fatal incidents are sub-divided into four categories, systemic poisoning, eye injuries, dermatitis, and chemical burns.

Results

Fatal incidents

During the period 1952-71, nine fatal cases of poisoning due to pesticides were investigated by the Safety Inspectorate (Table 1). Three of these (cases 1, 3, and 7) were the result of occupational exposure, while the remaining six were non-occupational but were reported to, and investigated by, the Safety Inspectorate because the incident happened to arise on, or in connection with, a farm.

The details of the nine fatalities are given below:

1955 Case 1, a nursery foreman in Essex, who had used ethyl mercury phosphate as a soil treatment for the last time the preceding April, died from

¹Available on application to the Pesticides Branch of the Ministry of Agriculture, Fisheries and Food, Ruskin Avenue, Kew, Richmond, Surrey.

TABLE 1
DEATHS AS A RESULT OF POISONING INCIDENTS DUE TO PESTICIDES IN ENGLAND AND WALES
INVESTIGATED BY THE PESTICIDES BRANCH,
MINISTRY OF AGRICULTURE, FISHERIES,
AND FOOD, 1952-71

Year	Case	Chemical	Affected individual
1955	1	Organomercury compound	Nursery foreman
1959	2	Arsenic	Farmer's wife
1960	3	Organophosphate	Scrapyard worker
	4	Fluoracetamide	Baby girl
1961	5	Cyanide	2-year-old child
1962	6	Nicotine	21-month-old boy
	7	Parathion	15-year-old nursery hand
1969	8	Paraquat	56-year-old labourer
1970	9	Organophosphate	Mental patient

organic mercurial poisoning. The coroner's verdict was reached after necropsy and expert medical evidence (Dr. P. L. Bidstrup). This case led to the withdrawal of this use of alkyl mercurial compounds.

1959 Case 2, a farmer's wife in Herefordshire, suffered fatal arsenical poisoning when the domestic water supply was contaminated by arsenic from a sprayer tank. Some of the contents of the sprayer tank accidentally syphoned back into the domestic supply to some farm cottages when the sprayer water was being replenished ill-advisedly with domestic water. Six others were affected in this incident but recovered.

1960 Case 3, a mentally retarded worker in a scrap metal yard in Ipswich employed in baling empty containers for disposal, died of organophosphate poisoning the same evening from dermal absorption of TEPP.

Case 4, a baby girl on a farm in Corby, Northamptonshire, who swallowed the contents of a 4oz bottle of fluoracetamide obtained from the drawer of a kitchen dresser, died 24 hours later in hospital.

1961 Case 5, the 2-year-old child of a farmworker in Staffordshire, died of acute cyanide poisoning after climbing into a nearly empty bin containing some sodium cyanide, which was being used for the destruction of wasps' nests.

1962 Case 6, the 21-month-old son of a Flintshire farmer, died of acute nicotine poisoning after drinking from an old tin of nicotine paint which had been used to destroy red-mite in a chicken house.

Case 7, a 15-year-old boy working in a nursery in Hatfield, employed in contravention of the regulations as a pesticide operator, died of parathion poisoning after applying the pesticide over a period of one week.

1969 Case 8, a 56-year-old labourer, took some paraquat from his place of employment for use in

his own garden. Although aware of its dangers, he kept it in a lemonade bottle in his garden shed, where he also stored his home-brewed beer in similar bottles. After swallowing a mouthful he realized his mistake and tried to make himself sick. He was admitted to hospital after four hours and died from respiratory failure due to pulmonary fibrosis 20 days after the incident.

1970 Case 9, a mental hospital patient who absconded and drank some organophosphorus insecticide from a container in a field where spraying operations were in progress, died as a result of his action.

Non-fatal incidents

During the period 1952-71, 395 non-fatal alleged incidents in England and Wales were reported to the Safety Inspectorate. Following investigation and assessment 222 of these incidents were confirmed. Between 1952 and 1966 (Figure) there was a gradually increasing number of incidents, rising from eight reported and six confirmed in 1952, to 16 reported and nine confirmed incidents in 1966. There was then a marked rise in the number of incidents reported, ending in 48 reported and 29 confirmed non-fatal incidents in 1971.

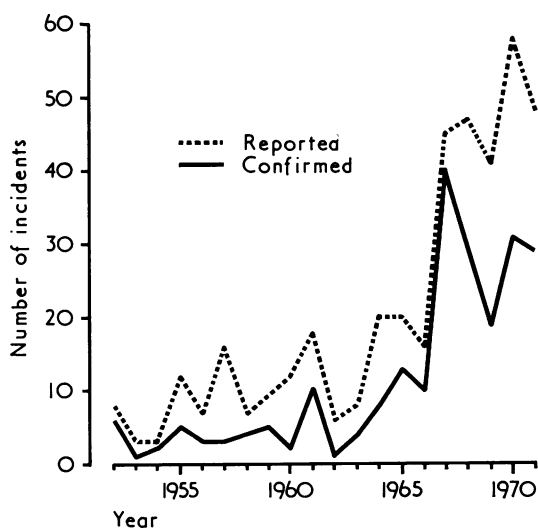


FIGURE Non-fatal reported and confirmed poisoning incidents in England and Wales investigated by the Pesticide Branch, Ministry of Agriculture, Fisheries, and Food, 1952-71.

Persons affected The confirmed non-fatal incidents affected a total of 296 persons (Table 2), comprising 28 farmers, 184 farmworkers, and 84 others. The others form a mixed group consisting of nurserymen, horticulturists, forestry workers, fieldsmen, and, occasionally, members of the public.

TABLE 2

PERSONS AFFECTED BY NON-FATAL POISONING INCIDENTS IN ENGLAND AND WALES INVESTIGATED BY THE PESTICIDES BRANCH, MINISTRY OF AGRICULTURE, FISHERIES, AND FOOD, 1952-71

Group	No.
Farmers	28
Farm-workers	184
Others	84
Total	296

Pesticide effects Confirmed non-fatal incidents are recorded in four categories in the Annual Report—systemic poisoning, eye injuries, dermatitis, and chemical burns.

Out of a total of 250 recorded pesticide effects (Table 3), 121 (48.5%) were due to systemic poisoning, 57 (22.8%) were eye injuries, 54 (21.6%) were dermatitis, and 18 (7.1%) were chemical burns.

TABLE 3

PESTICIDE EFFECTS IN ENGLAND AND WALES INVESTIGATED BY THE PESTICIDES BRANCH OF THE MINISTRY OF AGRICULTURE, FISHERIES, AND FOOD, 1952-71

Effect	Total	%
Systemic poisoning	121	48.5
Eye injury	57	22.8
Dermatitis	54	21.6
Chemical burns	18	7.1

Non-fatal systemic poisoning The causes of non-fatal poisoning incidents in England and Wales investigated by the Pesticides Branch between 1952 and 1971 are shown in Table 4. Of the 121 incidents, 34 were due to organophosphates, 26 to a single incident involving drift of chloropicrin, 15 to arsenites, eight to dinitro compounds, three to nicotine, two to fungicides, one to cyanide, and one to an organomercury compound, while 31 were not classified.

In many incidents, the worker complains of mild non-specific symptoms such as malaise, headache, upper respiratory irritation, and anorexia, usually disappearing in 24 to 48 hours, and he may have been exposed to a wide variety of agricultural chemicals. By the time the incident has been investigated by the Inspector, recovery from the episode is often complete, and when the medical expert is attempting to assess the case it is usually impossible to be dogmatic. Genuine cases of systemic poisoning are

TABLE 4
NON-FATAL SYSTEMIC POISONING INCIDENTS IN ENGLAND AND WALES INVESTIGATED BY THE PESTICIDES
BRANCH, MINISTRY OF AGRICULTURE, FISHERIES, AND FOOD, 1952-71

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Dinitro compounds	2	—	2	—	1	—	—	—	—	—	—	—	1	—	1	—	—	1	—	—
Organophosphates	2	—	—	4	—	1	4	4	1	5	1	—	2	—	—	6	—	2	2	—
Chloropicrin	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	26
Arsenites	—	—	7	—	2	—	6	—	—	—	—	—	—	—	—	—	—	—	—
Nicotine	1	—	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—
Fungicides	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—
Cyanide	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Organomercury compounds	..	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Non-classified	..	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	10	2	9	9
Total	5	0	2	11	4	4	10	1	7	1	0	5	1	2	6	10	5	11	35

recognizable and it is doubtful if any are missed, but there are a considerable number of very mild episodes accepted in which the relationship to pesticide exposure is extremely tenuous and it is certainly impossible to incriminate a specific chemical. The bias, probably correctly, is towards over-reporting and over-acceptance of dubious cases as attributable to pesticides.

The organophosphorus compounds involved in non-fatal systemic poisoning incidents between 1952 and 1971 are given in Table 5, together with their acute LD₅₀ values. Demeton-methyl accounted for 15 incidents, mevinphos for eight, while disulfoton, parathion, and schradan accounted for one incident each. In eight incidents the organophosphorus compound involved was not specified.

TABLE 5

NON-FATAL SYSTEMIC POISONING INCIDENTS DUE TO ORGANOPHOSPHORUS INSECTICIDES IN ENGLAND AND WALES INVESTIGATED BY THE PESTICIDES BRANCH, MINISTRY OF AGRICULTURE, FISHERIES, AND FOOD, 1952-71

Chemical	LD ₅₀ value (rat) ¹		Total
	Oral	Dermal	
Demeton-methyl (Metasystox)	50-75	300-450	15
Mevinphos (Phosdrin)	3-5	90	8
Disulfoton (Disyston)	4	50	1
Parathion ..	3-6	4-35	1
Schradan ..	5	50-100	1
Unspecified ..	—	—	8

¹The acute oral and dermal LD₅₀ values for the rat are from the Toxicology Laboratory, Chesterford Park Research Station, Fisons Limited Agrochemical Division (Ben-Dyke, R., Sanderson, D. M., and Noakes, D. N. (1970) *World Review of Pest Control*, 9, 119-127; Acute toxicity data for pesticides).

Eye injuries The causes of eye injury in England and Wales investigated by the Pesticide Branch between 1952 and 1971 are shown in Table 6. Paraquat accounted for six incidents, diquat for two, diazanon for two, and diesel oil, dinoseb, methyl chlorophenoxycetic acid, tetraethylpyrophosphate, and DDT/lindane/phenylmercury spray for one incident each. In 42 incidents the cause was not specified.

TABLE 6

CAUSES OF EYE INJURY, DERMATITIS, AND CHEMICAL BURNS DUE TO PESTICIDES IN ENGLAND AND WALES INVESTIGATED BY THE PESTICIDES BRANCH, MINISTRY OF AGRICULTURE, FISHERIES, AND FOOD, 1952-71

Cause	Eye injury	Dermatitis	Chemical burns
Paraquat ..	6	2	—
Organomercurial compounds ..	—	4	—
Sulphuric acid ..	—	—	4
Diquat ..	2	1	—
Diazanon ..	2	—	—
Thiram ..	—	2	—
MCPA ..	1	1	—
Diesel oil ..	1	1	—
DNBP ..	1	—	—
DDT/lindane/phenylmercury spray ..	1	—	—
TEPP ..	1	—	—
Demeton-methyl ..	—	1	—
Dicamba/TBA ..	—	1	—
Dinitroresol ..	—	1	—
2-4D ..	—	1	—
Maneb ..	—	1	—
Metham sodium ..	—	1	—
Sodium arsenite ..	—	1	—
Zineb ..	—	1	—
Hydrofluoric acid ..	—	—	1
Phenol ..	—	—	1
Not specified ..	42	35	12
Total ..	57	54	18

Dermatitis The causes of dermatitis in England and Wales investigated by the Pesticides Branch between 1952 and 1971 are also shown in Table 6. Organomercurial compounds accounted for four cases, paraquat for two, thiram for two, while diesel oil, demeton-methyl, dicamba/TBA, dinitrocresol, diquat, 2-4D, maneb, metham sodium, methylchlorophenoxyacetic acid, sodium arsenite, and zineb accounted for one case each. In 35 instances the actual cause of the dermatitis was not specified. There is much doubt on the validity of these figures for dermatitis; the establishment of the causal factor is just as difficult and as rare in agriculture as in other occupations.

Chemical burns The causes of chemical burns in England and Wales investigated by the Pesticides Branch between 1952 and 1971 are shown again in Table 6. Sulphuric acid accounted for four examples, while hydrofluoric acid and phenol accounted for one each. In 12 incidents, the cause of the chemical burn was not specified.

Discussion

Of the nine deaths due to agricultural chemicals investigated by the Pesticides Branch between 1952 and 1971, only three were the result of occupational exposure and only one of them actually involved an agricultural worker. He had been working as a nursery foreman using ethyl mercury phosphate as a soil treatment and his death in 1955 led to the withdrawal of alkyl mercurial compounds for this purpose. One of the fatalities from organophosphorus poisoning was unusual in that the individual should not have been working in the capacity which led to his death. He was a boy of 15 who was being employed as a pesticide operative in direct contravention of the regulations relating to the use of agricultural chemicals.

The death of the farmer's wife in 1959, in Herefordshire, from acute arsenical poisoning, together with the non-fatal poisoning of six others using the same domestic water supply, was the result of carelessness. Of the remaining two deaths of adults, that of the absconding mental patient who drank some organophosphorus insecticide from a container in a field where spraying operations were in progress was a bizarre isolated incident almost impossible to prevent. The death due to accidental swallowing of paraquat was again the result of culpable stupidity. It is difficult to credit that an individual actually aware of the hazards of the material should expose himself to such a danger by storing the chemical in the same shed and in a bottle similar to those he used for his home-brewed beer. The tragic deaths of three infants emphasizes Schilling's (1972) statement that the farm is not a safe place for children.

Nonetheless, three occupational deaths over the period 1952-71 is a remarkably low figure. In the field of agriculture there were 28 deaths due to tractor accidents in the single year of 1971, while the construction industry contributed 196 deaths in the same year.

The marked rise in the reported non-fatal incidents since 1966 largely reflects growing public awareness and apprehension, together with a tendency to report the trivial and sometimes even the ludicrous to a much greater extent than in earlier years. An analysis of the confirmed non-fatal incidents suffers from the disadvantages and limitations of any retrospective survey. The details of recording by the Inspectorate have altered over the years and, in particular, have become much more comprehensive and complete since 1966, accounting to a very great degree for the apparently increased incidence. Another difficulty is that the total quantity of different agricultural chemicals actually applied during this period is not known and clearly this is directly related to the risk of poisoning. Production has, however, been rising by about 8% per annum (Edson, personal communication).

During the period 1952-71, there were 121 cases of non-fatal systemic poisoning, an average of six per annum, showing a slight increase in incidence in later years (Table 4). However, the relative severity of the cases seen in earlier years contrasts with the mildness of the recorded episodes from 1966 onwards. The mildness is reflected in the increased number of cases recorded as unclassified. These are mild illnesses with non-specific symptoms occurring in agricultural workers who may have been exposed to a wide variety of chemicals. In some of the incidents recorded as unclassified these symptoms may well have been unrelated to occupational exposure. In earlier years typical clinical symptoms permitted definite classification according to the causative chemical. Apart from this alteration in clinical severity, poisoning due to dinitro compounds has become less frequent in recent years, while the incidence of organophosphorus poisoning remains approximately the same. Poisoning due to arsenites, sodium arsenite in particular, accounted for 15 cases up to 1959, but there has been none since. In the case of eye injuries, dermatitis, and chemical burns, the possibility of under-reporting has to be considered. As the vast majority of recorded instances are relatively trivial it appears unlikely that many significant episodes escaped the attention of the Inspectorate. Eye injury is almost invariably the result of the careless decanting of active material without using an eye shield.

In an era of chemical McCarthyism, the overall safety of pesticide application needs emphasis. In 1946 a committee was set up under the Chairmanship of Sir Ernest Gowers to enquire into matters of

'Health, Welfare, and Safety in Non-industrial Employment'. In the Committee's Report to Parliament in 1949 (Home Office, 1949), a recommendation was made that legislation should provide for the provision of protective clothing by the employer for employees using fertilizers, sprays, chemicals, and other dangerous substances. The increasing use of agricultural chemicals led to the formation of a working party under the Chairmanship of Professor (later Lord) Zuckerman. The reports of the Zuckerman Working Party and their recommendations (Ministry of Agriculture and Fisheries, 1951; 1953; 1955), resulted in the passage of the Agriculture (Poisonous Substances) Act in 1952, with subsequent Regulations, and in the creation of a voluntary notification scheme, later known as the Pesticides Safety Precaution Scheme. Under the scheme, manufacturers notify the Ministry of Agriculture, Fisheries, and Food before marketing any new chemical or recommending the new use of an existing one. Extensive toxicological data are provided by the manufacturers and are assessed by the Government's Advisory Committee on Pesticides and Other Toxic Chemicals and its Scientific Subcommittee. Further testing may be required. When the Committee recommend the use of the chemical, its safety has been fully examined in relation to the user, the general public, animals, and wild life. If the Ministry accept the recommendations the chemical is cleared for use. It is a condition of clearance that the recommended conditions of use and safety precautions are set out on the label. In particular, the list procedure, by which chemicals are graded according to their toxicity, and the Poisons Rules are of especial importance. These ensure that 'cleared' chemicals of high toxicity are just not available to the ordinary gardener or member of the public but are allowed to be sold only to the professional user. The safety of pesticide application in this country owes much to this intelligent and enlightened co-operation between the manufacturers and the Government.

However, the main problems in the use of pesticides in England and Wales are not primarily toxicological. The irresponsible or illicit removal of concentrate from labelled bulk containers into plain bottles is probably the most serious. The classical example is paraquat, which is not on sale as such to the general public. The individual with access to a supply appropriates some and dispenses it among his weed-troubled friends with results too well known to repeat. It is salutary to remember that not a single death has occurred from the normal use of paraquat and that it is a herbicide of unparalleled and revolutionary advantages that can even, in certain instances, remove the need for the plough.

The hoarding of oddments of pesticides in stores on farms, or worse still in the drawers of kitchen

dressers, comes second to irresponsible decanting. Odds and ends of incompletely used cans of pesticides are kept as they are replaced by newer and allegedly better ones. Time can obliterate the label and the contents can become unrecognizable. An organization orientated specifically towards education of the farmer would help to control this hazard. The disposal of empty containers of agricultural chemicals is still a problem. Partly full and unwashed containers are not infrequently discarded around farms, by the roadside, or in ditches. Empty plastic containers are used for other purposes. There are physical difficulties involved in the crushing and disposal of the larger, stronger metal containers, and there is a need for an efficient container disposal system under arrangements with the local authorities. The inadequate labelling of imported containers of pesticides is a serious problem. With some imported containers there is either no labelling at all or else it is only in the language of the country of origin. There is no control over such importation, which is attractive to the farmer as such products are often cheaper, and this is a legislative defect which should be remedied. These defined practical problems of safety in application and accident control are perhaps of greater importance than the long-term theoretical toxicological effects of individual pesticides which may be attracting too much attention today.

This article is based on a paper originally presented to the Royal Society of Medicine on 13 April 1972. Acknowledgements are especially due to Dr. E. F. Edson for constructive criticism and for unfailing help to me in dealing with pesticide problems since 1959. Thanks are also due to Dr. J. M. Barnes for helpful advice, and to Mr. J. Weeks, Chief Safety Inspector, and his colleagues at the Ministry of Agriculture, Fisheries, and Food for ready co-operation and for many useful discussions on a common problem.

References

- Edson, E. F. (1955). Emergencies in general practice. Agricultural pesticides. *British Medical Journal*, 1, 841-844.
- Home Office (1949). *Health, Welfare, and Safety of Non-industrial Employment. Hours of Employment of Juveniles*. Report by a Committee of Enquiry. (Chairman, Sir E. A. Gowers) Cmd. 7664. H.M.S.O., London.
- Ministry of Agriculture and Fisheries (1951). *Toxic Chemicals in Agriculture*. Report of the Working Party (Chairman, Lord Zuckerman). H.M.S.O., London.
- (1953). *Toxic Chemicals in Agriculture: Residues in Food*. Report of the Working Party (Chairman, Lord Zuckerman). H.M.S.O., London.
- (1955). *Toxic Chemicals in Agriculture: Risks to Wildlife*. Report of the Working Party (Chairman, Lord Zuckerman). H.M.S.O., London.
- Schilling, R. S. F. (1972). Occupational health in Great Britain in 1970. *British Journal of Industrial Medicine*, 29, 221-224.

Received for publication September 17, 1972.

Accepted for publication February 13, 1973.



A review of agricultural pesticide incidents in man in England and Wales, 1952-71

C. E. D. Hearn

Br J Ind Med 1973 30: 253-258
doi: 10.1136/oem.30.3.253

Updated information and services can be found at:
<http://oem.bmj.com/content/30/3/253>

These include:

Email alerting service

Receive free email alerts when new articles cite this article.
Sign up in the box at the top right corner of the online article.

Notes

To request permissions go to:
<http://group.bmj.com/group/rights-licensing/permissions>

To order reprints go to:
<http://journals.bmj.com/cgi/reprintform>

To subscribe to BMJ go to:
<http://group.bmj.com/subscribe/>